WHITE PAPER on
THE NUTRITIONAL AND HEALTH BENEFITS OF SALMON

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Health & Nutritional Benefits of Salmon

The primary purpose of this paper is to present up-to-date information on the health and nutritional benefits of salmon. Inclusive to this report are current dietary recommendations for fatty acids, specifically omega-3 polyunsaturated fats, the Position of Health Canada and The World Health Organization (WHO) on the safety of fish consumption, and Recommendations of the American Dietetic Association (ADA) and Dietitians of Canada (DC) on weekly fish consumption.

This paper will provide a comprehensive report on the current literature pertaining to the health benefits of omega-3 fatty acids specific to each life stage - namely, pregnancy, lactation, childhood, adulthood and aging. Furthermore, this paper will look at omega-3's in the marketplace and emphasize the importance of consumer awareness on the difference between the three omega-3 fats.

Background

There has been a lot of interest lately, by consumers and health professionals alike, on the numerous health benefits of omega-3 fatty acids, specifically eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). In light of this, foods high in this unique type of health-promoting fat, including salmon, have been placed in the spotlight.

Salmon is one of the richest known food sources of omega-3 polyunsaturated fat. Additionally, salmon is high in protein yet low in calories and saturated fat, making it a desirable meat alternative and an excellent protein choice. Salmon is also an excellent source of selenium, a very good source of niacin and vitamin B12, and a good source of phosphorus, magnesium and vitamin B6 (1).

Table 1 compares the nutrient value of salmon to some other some common protein choices, with emphasis on calorie, protein, saturated fat, and polyunsaturated fats.

Table 1: Nutrient values of some common protein foods

Protein Sources	Measure	Calories (kcal)	Protein (g)	Saturated Fat (g)	Polyunsaturated Fat (Omega-3) (g)	
					ALA	EPA + DHA
Salmon, Atlantic farmed, baked or broiled	75g	154	16.58	1.88	0.09	1.610
Salmon, sockeye, red, baked or broiled	75g	162	20.48	1.44	0.046	0.922
Halibut, Atlantic or Pacific, baked or broiled	75g	105	20.02	0.32	0.062	0.349
Beef, strip loin steak, lean, broiled	75g	161	24.17	2.74	0.038	0.00
Pork, loin centre cut, lean, broiled	75g	165	23.96	2.72	0.00	0.00
Chicken, breast meat, roasted	75g	119	24.6	0.44	0.013	0.014
Egg, chicken, whole, fried	75g	151	10.22	3.23	0.090	0.033
Tofu, firm or extra firm	75g	95	10.58	0.68	0.136	0.00

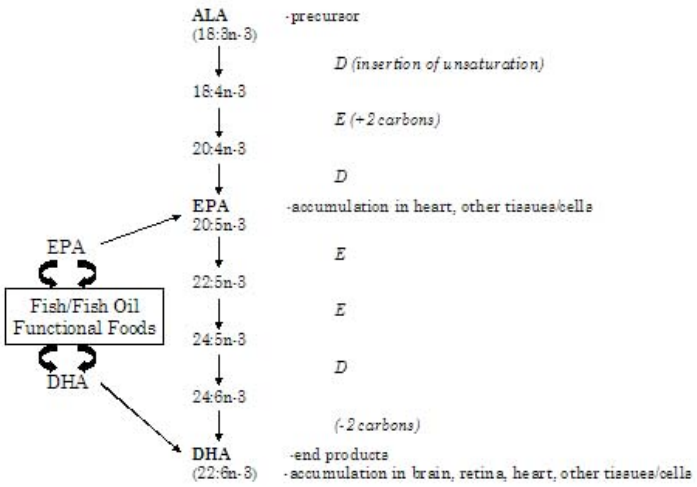
(2)

Omega-3: The Essential Fatty Acids

The three essential fatty acids, Alpha-linonenic Acid (ALA), Eicosapentaenoic Acid (EPA) and Docosahexaenoic Acid (DHA), differ in their metabolic and physiological roles. ALA found in plant sources like flax, canola and soy, is the precursor to DHA and EPA. EPA and DHA are found mainly in fatty fish such as salmon, trout, mackerel, and sardines (3-4).

As their name implies, essential fatty acids are essential for human health; because they cannot be made by the body, they must be obtained from foods. EPA and DHA can be made by the body from the essential fatty acid alpha-linolenic acid (ALA), but since the metabolic conversion of ALA to DHA/EPA is limited in humans, the most direct way of providing DHA plus EPA for the body is via their direct consumption. Figure 1, below, illustrates the metabolic pathway and conversion of ALA to EPA and DHA (5).

Figure 1: Conversion Efficiency of ALA to DHA in Humans



DHA/EPA Omega-3 Institute, Conversion Efficiency of ALA to DHA in Humans. Available from: http://dhaomega3.org

Position of the American Dietetic Association and Dietitians of Canada on Dietary Fatty Acids

The American Dietetic Association (ADA) and Dietitians of Canada (DC) recommends 20 to 35% of total calories from dietary fat (44 - 78 grams fat/day). Implicit to these recommendations is that unsaturated fatty acids be the predominant fat source in the diet, with emphasis on increasing omega-3 polyunsaturated fatty acids and reducing intake of saturated and trans fatty acid (6).

The recommended intakes for omega-3 fatty acids, for a healthy adult population, range from 0.6% to 1.2% of energy (1.3 to 2.7 g/day). In addition, the long-chain omega-3 fatty acids, DHA + EPA, should provide a sum total of 500 mg per day for overall health (6).

The Food and Nutrition Board in the United States (2005) have established recommended Adequate Intakes (AI) for n-3 polyunsaturated fatty acids for each life stage group. A summary of these recommendations is provided in Table 2. The term AI refers to the recommended average daily intake level based on observed or experimentally determined approximations or estimates of nutrient intake via

a group (or groups) of apparently healthy people that are assumed to be adequate - used when an RDA (recommended dietary allowance) cannot be determined (7).

Table 2: Recommended Adequate Intakes (AI) for Omega-3 Fatty Acids

Life Stages	Age	Males (g/day)	Females (g/day)
Infants	0-6 mos	0.5	0.5
Infants	7-12 mos	0.5	0.5
Children	1-3 yrs	0.7	0.7
Children	4-8 yrs	0.9	0.9
Children	9-13 yrs	1.2	1.2
Children	14-18 yrs	1.6	1.1
Adults	19 yrs and older	1.6	1.1
Pregnancy	All ages	n/a	1.4
Breastfeeding	All ages	N/a	1.3

(7)

Although no AI has been set for each of the three fatty acids, up to 10% of the above amounts may be in the form of DHA + EPA (7).

Recommendations for Weekly Fish Consumption & Mercury Exposure

Health Canada last issued consumption advice about mercury in fish in 2002. That advice is now being updated to better reflect the latest data on mercury levels in retail fish and the current consumption habits of Canadians, as well as to help Canadians make more informed decisions about the food they eat (8).

The current position of Health Canada is that, "Most Canadians don't need to be concerned about mercury exposure as a result of fish consumption" (8). Dietitians of Canada and *Canada's Food Guide (2007)* recommend at least two servings (150g) of fish a week (9).

Children, pregnant and breastfeeding women and women who may become pregnant can particularly benefit from the nutrients offered by fish (8-9). However, because the developing fetus and young children are also most at risk from mercury exposure, Health Canada emphasizes the importance for these groups to be aware of what types of fish are a good choice for frequent consumption and which should be eaten less often. Fish and shellfish that contain higher levels of these fatty acids and are also low in mercury include: anchovy, capelin, char, hake, herring, Atlantic mackerel, mullet, pollock (Boston bluefish), *salmon*, smelt, rainbow trout, lake whitefish, blue crab, shrimp, clam, mussel and oyster (8).

Table 3 illustrates current recommendations by Health Canada for fish consumption in Canada, by age and population group. Note: 150 grams represents two Food Guide servings and is equivalent to approximately one cup.

Table 3: Recommended Weekly Fish Consumption for Canadians

General Population	Specified Women*	Children 5-11 years	Children 1-4 years
150 g per week	150 g per month	125 g per month	75 g per month

* Specified women are those who are or may become pregnant or are breastfeeding (8).

Omega 3-s in Food Products

With recent attention on the health benefits of omega-3 fats, grocery store aisles are now filled with food products bearing the claim "source of omega-3 polyunsaturates". In accordance with Canadian food labelling regulations, packaged foods may carry this claim if they contain ≥0.3g of omega-3 per serving (3,10). This same claim can be made whether the omega-3 comes from DHA, EPA or ALA. Products with this claim must list the omega-3 content in the Nutrition Facts table although, it is not possible to discern how much of each fatty acid is present unless it is clearly stated on the package (10). Additionally, Canadian regulations allow a biological role claim for DHA-containing products namely, "DHA, an omega-3 fatty acid, supports the normal development of the brain, eyes and nerves" (11).

The table below illustrates that the amount of omega-3 in products varies greatly, as does the type of omega-3 also varies.

Table 4: Omega-3 content (ALA versus EPA+DHA) in some common food products and supplements

Food	ALA (g)	DHA+EPA (g)
Atlantic salmon, farmed (75 g)	0.09	1.61
Atlantic salmon, wild (75 g)	0.28	1.34
Rainbow trout (75 g)	0.06	0.86
Nordic Naturals Omega-3 Supplement (1)	0.14	0.55
Naturegg Omega Pro Eggs (1)	0.27	0.13
Becel Omega3Plus Margarine (2 tsp)	0.55	0.05
Danone Danino Yogurt (100 g)	0.06	0.04
So Good Omega Original (1 cup)	0.70	0.00
Flaxseed oil (1 tsp)	2.40	0.00
Canola oil (1 tsp)	0.40	0.00
Source Cardio Yogurt (100 g)	0.30	0.00

(3)

The concern raised by Dietitians and other health professionals alike, is for the consumer. Unfortunately, most people are unaware that 'omega-3' is an umbrella term for three different dietary fatty acids – ALA, EPA and DHA (3). The majority of studies that support the health benefits of omega-3's focus on DHA and EPA, not ALA. However, market research shows that people are still trying to eat more omega-3 fat, and are purchasing products with high amounts of ALA and little, or no, DHA and EPA (12-13). This research suggests that more information and resources need to be made available to inform the consumer of the difference between the three types of fatty acids, and the best foods choices of the omega 3 fats DHA and EPA.

Omega-3 Fatty Acids Through the Life Stages

DHA and EPA have been studied for their beneficial effects on cardiovascular health, cancer prevention and management, eye and visual health, mental health, cognitive performance, body composition and weight management, inflammatory diseases, immune and nervous system disorders and skin conditions, to name a few (14).

It is beyond the scope of this paper to summarize evidence for each health condition however, an excellent overview is provided by The US National Library of Medicine and the National Institutes of Health. A full report can be found at www.nlm.nih.gov/medlineplus/druginfo/natural/patient-fishoil.html.

Instead, this paper will focus on the benefits of omega-3 fatty acids at each life stage namely, pregnancy, lactation, childhood, adulthood, and aging – and their associated contribution to human health.

Pregnancy

The primary function of long-chain omega-3 fatty acids in mothers is to support the optimal health of the baby during pregnancy, after birth (during infancy), and during the subsequent childhood period as well as providing for the health and physiological needs of the mother (15).

DHA plays a key role in optimal brain functioning of the infant (cognitive performance) and retinal performance (optimal visual acuity). Since ALA (found in certain plant foods such as flax, canola oil, walnuts) is very poorly converted via metabolism to DHA, the most direct and efficient means of supplying DHA to the mother for transfer to the developing baby during pregnancy is via DHA consumption (15).

A recent Canadian study indicated that the consumption of two-three servings weekly of farmed salmon, wild salmon, or rainbow trout, would provide a daily averaged DHA intake of at least 300 mg/day during pregnancy, and would not approach the tolerance levels for mercury, polychlorinated biphenyls, or dioxins and furans as set by Health Canada, the NRC (U.S.), or the World Health Organization (16).

Lactation

As mentioned above, DHA is an essential nutrient and a key omega-3 fatty acid needed in high levels in the brain and retina (eye) for optimal neuronal functioning (learning ability, memory) and visual acuity, respectively.

For breast-fed infants, their only source of nutrition, including DHA, for growth and development is their mother's milk. The amount of DHA in the diet is a major factor determining how much DHA appears in breast milk for the baby to consume for health (15).

Although the North American diet commonly includes high amounts (up to 1300mg/day) of the omega fat ALA, we now know that ALA is very poorly converted to DHA in the human body (17). Additionally, studies have shown that an increase in ALA does not increase the level of DHA in breast milk, while direct consumption of DHA, even at relatively low levels, provides a fairly rapid and marked improvement in the DHA level found in breast milk (18-19).

Childhood

The Food and Nutrition Board in the U.S. (2005) has set an AI target of 0.7, 0.9 and 1.2 grams per day of ALA (omega-3) for children (both genders) aged 1-3, 4-8, 9-13 years, respectively. While no specific mandatory requirements for DHA or DHA/EPA is set, the Board does indicate that up to 10% of the AI for ALA (omega-3) could be in the form of DHA + EPA (combined); 70, 90, and 120 mg/day, respectively (7).

A few studies have appeared in the literature evaluating the potential effects of supplementation with omega-3 fatty acid as DHA plus EPA in children with dyslexia or ADHD (attention-deficit/hyperactivity

disorder). DCD is a condition that affects approximately 5% of school-aged children (including core deficits in motor function, difficulties in learning, behavior, and psychological adjustments that persist into adulthood) (20).

The recently reported Oxford-Durham Study from the U.K. has had a major impact on consideration being given to the potential beneficial effects of increased intakes of DHA plus EPA on DCD/dyspraxia. Supplementation of 170 mg of DHA plus 558 mg of EPA for a 3-month period resulted in a net improvement in reading age by 6 months, spelling age by 6 months, and also significant behavioral improvements (hyperactivity, inattention, anxious/shy behavior, cognitive problems, and restless-impulsive characteristics) (21).

Adulthood

The Food and Nutrition Board in the U.S. (2005) has set an AI target, for adults 19 years and older, of 1.6 grams per day for men and 1.1 grams per day for women. As with the recommendations set for children, there is currently no Adequate Intake (AI) level for DHA or EPA specifically. It is indicated, in these recommendations, that 10% of the AI for ALA (omega-3) could be in the form of DHA + EPA. In quantitative terms, it is suggested that daily intake of DHA/EPA (combined) be that of 160 mg for adult men, and 110 mg per for adult women (7).

The NIH Workshop held in 1999 in Bethesda, Maryland consisting of scientific experts and research in the omega-3 fatty acid area from various countries provided recommendations on intakes of DHA plus EPA for normal subjects in order to promote optimal health and cardiovascular care (22). Based on a 2000 kcal adult diet, it was recommended that DHA plus EPA combined should represent 0.3% of total energy with DHA and EPA each representing at least one-third of the mixture, ie, at least 0.1 energy % each. In quantitative terms, these intakes correspond to 650 mg of DHA plus EPA (combined) with DHA being consumed at the level of at least 220 mg/day and EPA at the level of at least 220 mg/day. It is noteworthy that the average North American intake of DHA plus EPA combined is approximately 120-150 mg or about one-fifth of the AI (Adequate Intakes) for adults recommended by experts at the Workshop (22).

Aging

Included in recommendations made for adults 19 years and older, DHA plus EPA (combined) should be consumed at the level of at least 650 mg/day with at least one-third of the mixture being represented by each of the two fatty acids (22).

Many studies suggest that adults, 65 years of age and older, would benefit from even higher intakes of DHA/EPA. These studies show that supplementation of 700mg/day omega fatty acids (from fish oil) result in a slower rate of decline in cognitive scoring with age, improved retention of cognitive function, and significantly lower risk of developing a stroke (23-26).

<u>Conclusion</u>

Salmon certainly lives up to its reputation as a superfood. In addition to being a low fat protein choice, salmon is one of the richest, and most direct, food sources of omega-3 fatty acids - EPA and DHA.

As this paper has illustrated, omega-3 fatty acids are an essential part of the Canadian diet throughout each life stage. The DHA/EPA Omega-3 Institute suggests that Canadians are not eating enough of these beneficial omega-3 fats (27).

There are a multitude of food sources of omega-3 fats in the marketplace yet, as this paper has shown, the majority of these products lack DHA and EPA - the two fatty acids researched in human health studies. With increased awareness on omega-3 fatty acids, Canadians will be able to make more informed food choices and reap the health benefits of this essential nutrient. As demonstrated, regular consumption of salmon, and other fatty fish, is an efficient and safe means of providing adequate omega-3 (DHA and EPA), in our diet.

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